Date:	January 23, 1962
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Subject:	WANL-TNR-011 (Revision)

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Attached is your copy of revised Fig. 1 of WANL-TNR-011, "Properties of Graphite Cloth," dated January 16, 1962. Please insert this sheet and destroy the Fig. 1 you now have.

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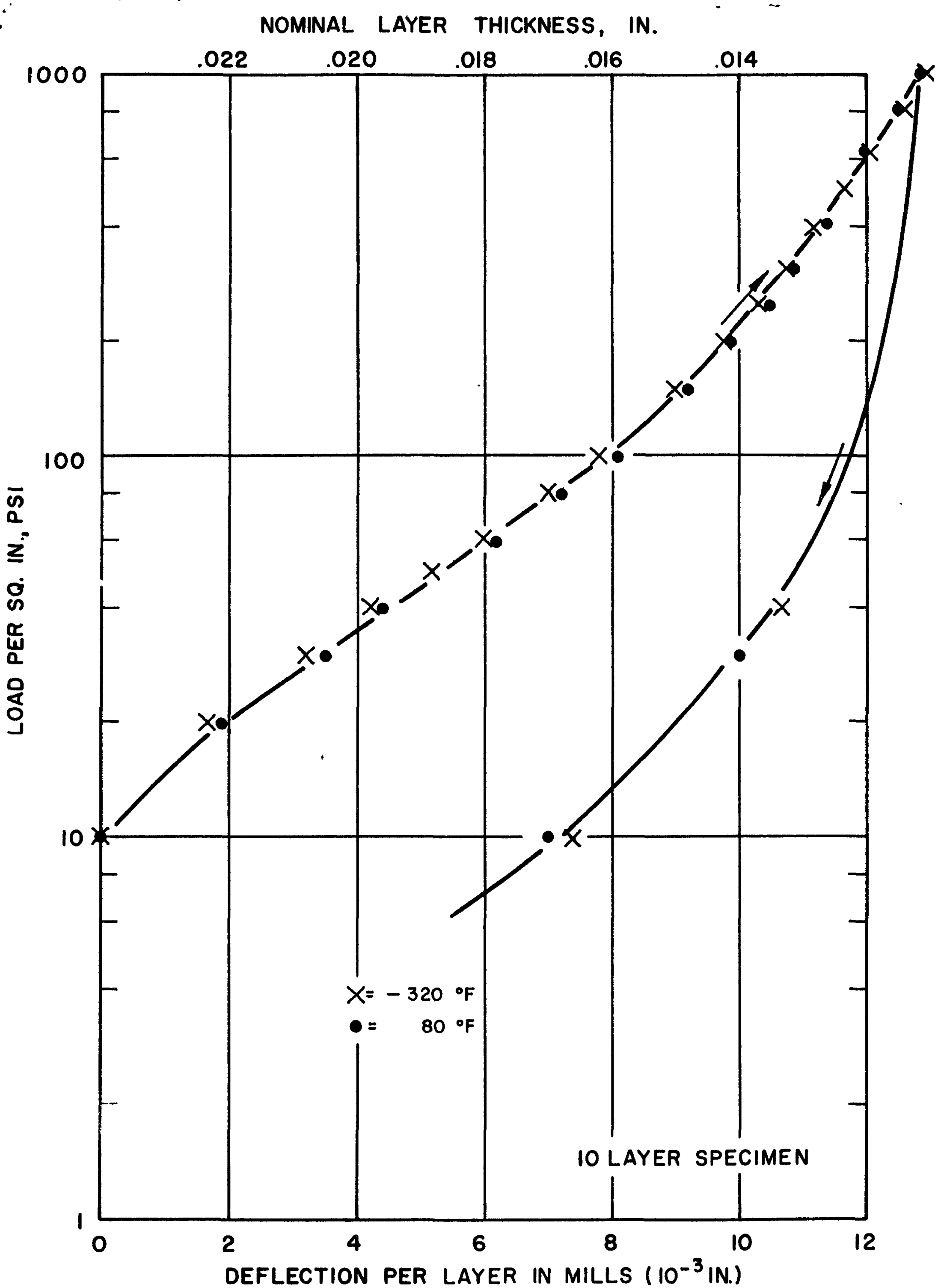

Fig. 1 COMPRESSION TESTS OF GRAPHITE WCB CLOTH AT - 320F and 80F

Astronuclear

WANL-TNR-011

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PROPERTIES OF GRAPHITE CLOTH NERVA NUCLEAR SUBSYSTEM

ABSTRACT

PROPERTIES OF GRAPHITE CLOTH

Graphite cloth can be precompressed to form a resilient graphite spring. The room temperature resilience is maintained at -320F. High damping can be expected under vibratory loading because of the large hysteresis loop. Creep will occur in a pack of layered cloth which will result in some additional compressibility with time under constant loading pressure or relaxation of the pressure under constant deflection.

The static coefficient of friction in air of graphite cloth on graphite cloth is 0.3 and that for cloth on steel is about 0.2.

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PROPERTIES OF GRAPHITE CLOTH

1.0 INTRODUCTION

This report summarizes the physical properties of a graphite cloth which has possibilities as lateral-support material for reactor cores. The results of an experimental program on compressibility of this material are given. Tests were made at room temperature and liquid nitrogen temperature to determine the influence of low temperature on the fracture characteristics of the brittle graphite fibers. Friction measurements were made at room temperature for combinations of graphite cloth on graphite blocks, graphite cloth on graphite cloth, and graphite cloth on steel.

Material: This graphite cloth was formed by processing cloth of organic fibers at temperatures up to 5400F by the National Carbon Company and is designated as Grade WCB. The individual fibers are high purity graphite and have a strength about 100 times that of standard forms of graphite. Thus, the cloth has good flexibility, resistance to thermal shock, and fair resistance to mechanical abuse. General information supplied with this grade are listed below:

TABLE - GRAPHITE CLOTH WCB

Weight	6.5 to 8.4 ounces/sq. yd.
Weave	Plain type
Count	27 x 25 threads/inch (approx.)
Gage	0.021 to 0.028 inches
Denier and Ply, Warp and fill	950/1
Filaments per ply	1440
Filament dia.	0.0002 inches
Purity	99.9% + carbon, ash 0.04%

Tensile Strength, 70F	5 to 16 pounds/inch width
Specific heat, 70F	0.16 (approx.)
Emissivity	0.9 (approx.)

2.0 COMPRESSIBILITY TESTS

2.1 Comparison of Compressibilities at Room Temperature and Cryogenic Temperature

A pack of 10 layers of 2 x 2" squares of cloth were utilized as a test sample for the compressibility tests. This pack was placed between hardened and ground steel platens of a conventional testing machine and compressed. The deflection of the platens was measured by a strain-gauge clip extensometer and the load-deflection curve was autographically recorded. The curves for virgin samples tested at 80F and -320F, respectively, are plotted in Figure 1. Because of the large range of loading, the load in pounds per square inch is plotted logarithmically. The remarkable agreement of the curves shows that the low temperature does not result in a change of rigidity or loss of flexibility and ductility. The maximum loading of 1000 psi is much greater than that contemplated for service. The set is large, but is not increased by the lower temperature and much of it is recovered when the load is completely removed.

2.2 Loading Hysteresis

To determine the hysteresis of the loading curve over a range of loadings, a specimen was loaded from approximately three psi to various peak loads. The points in Figure 2 are marked as to the sequence of loading. Corresponding unloading points are suffixed with the letter D. To avoid confusion, only the loading curves are shown for the first five loadings. The complete curve is given for the sixth loading. The final or "shakedown" curve is that obtained after repeating the sixth loading for 10 cycles. The loading curve became more stable after each cycle. This large hysteresis loop will effect considerable damping if the cloth is used as a spring.

2.3 Friction of Graphite Cloth

The use of graphite cloth as a lateral support may result in relative motions between the layers of cloth or between the cloth and the adjacent materials. The following table lists the average coefficients of static friction for the pressure range of 10 to 50 psi.

TABLE II

STATIC FRICTION OF GRAPHITE CLOTH WCB AT ROOM TEMPERATURE IN AIR

Material Combination	Static Coefficient of Friction
Graphite Cloth on Graphite Cloth	0.3
Graphite Cloth on Graphite	0.25
Graphite Cloth on Steel	0.19

The dynamic coefficient of friction for graphite cloth on cloth or graphite was considerably lower than the static one, but for graphite cloth on steel, it was only 10 to 15% lower than the static one.

These friction values would be considered as tentative values because of the variability of the surface conditions of the samples of cloth and mating materials. It has also been found that the friction may change rapidly on rubbing because of surface pick up.

2.4 Relaxation of Graphite Cloth

The steep unloading curves shown in Figures 1 and 2 will result in a large decrease of stress or load when the cloth is used as a support spring and creep occurs. The sources of creep are creep in the individual fibers, slip between fibers, nesting of layers because of the weave, and lateral buckling of threads. The relaxation of the stress, load per unit-area, from an initial pressure of 200 psi is shown as a function of time at room temperature in Figure 3. Since the density of the cloth and its rigidity increase as it is compressed, the stress will relax to some limiting value at long times.

3.0 SUMMARY

Graphite cloth can be precompressed to form a resilient support. The compressibility at -320F is the same as that at room temperature. The loading deflection of the cloth is nearly proportional to the log of the surface pressure. A large hysteresis loop develops in a loading cycle which will effect high damping under vibratory loading.

The static coefficient of friction of graphite cloth on graphite cloth is 0.3 which is relatively high. It is about 35% lower for graphite cloth on steel.

Because of creep in a pack of layered cloth, relaxation of the pressure will occur under a constant deflection.

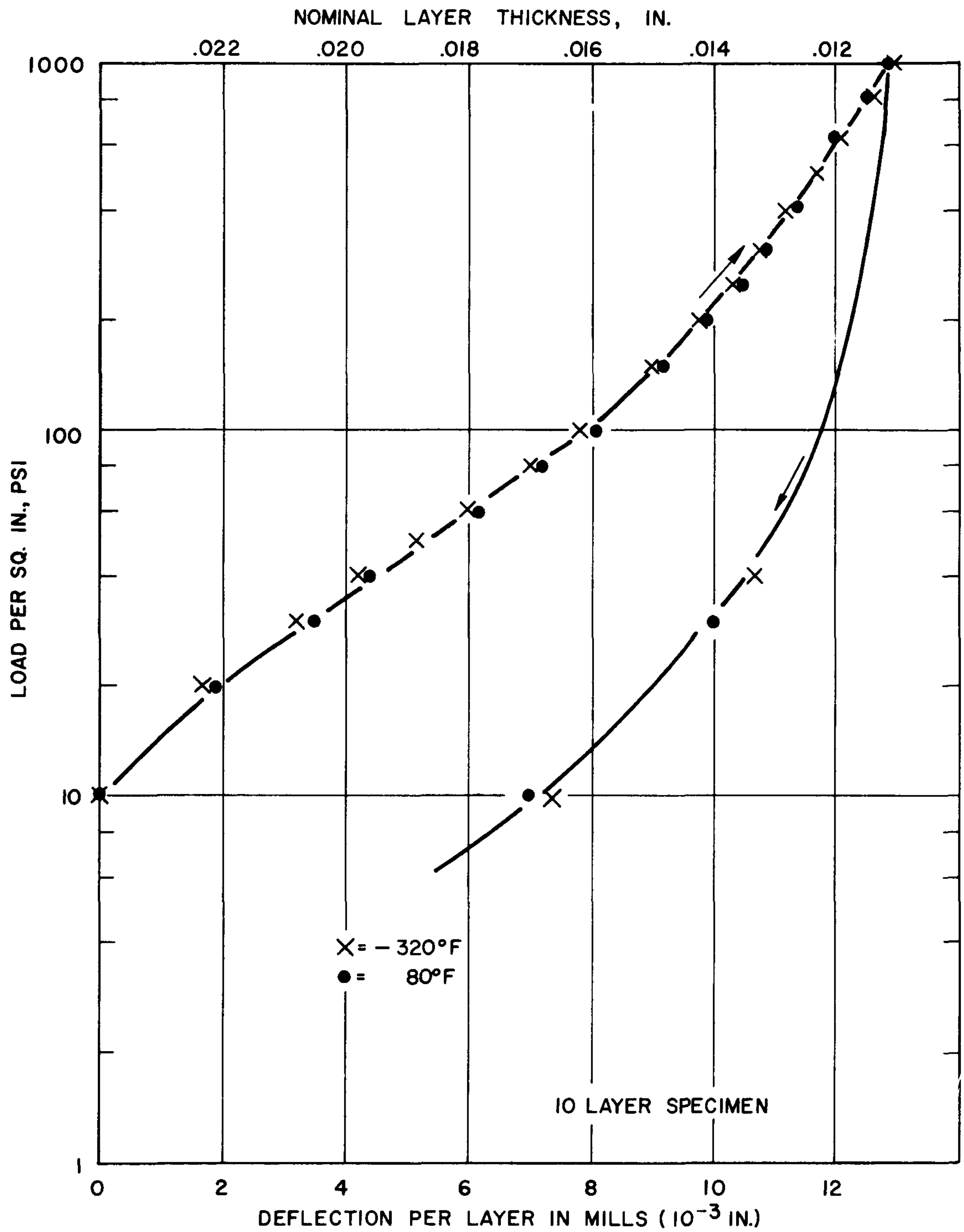

Figure 1 537365

Compression Test of Graphite WCB Cloth at -320 F and 80 F

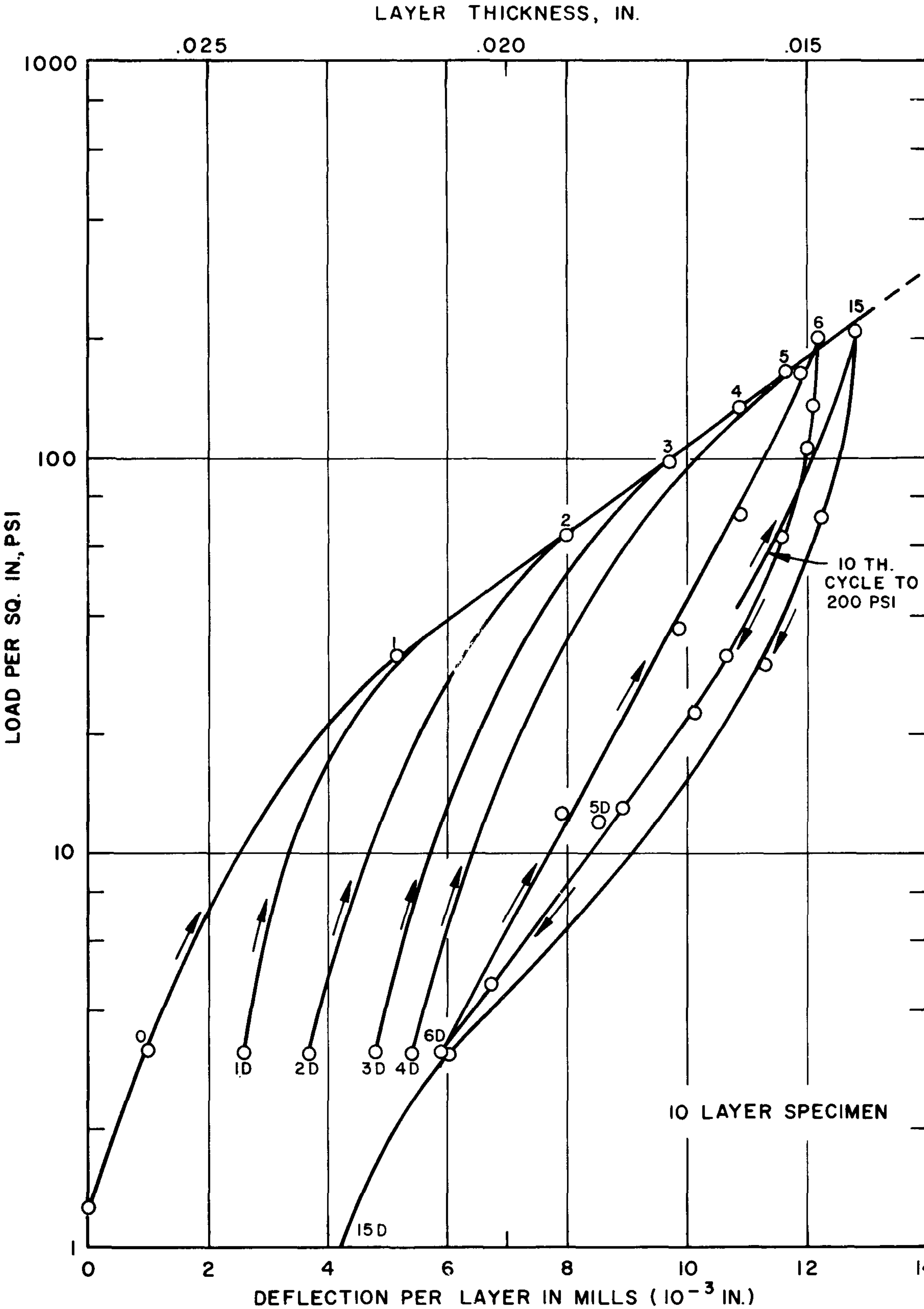

Figure 2 537367

Room Temperature Compression Test Graphite WCB Cloth

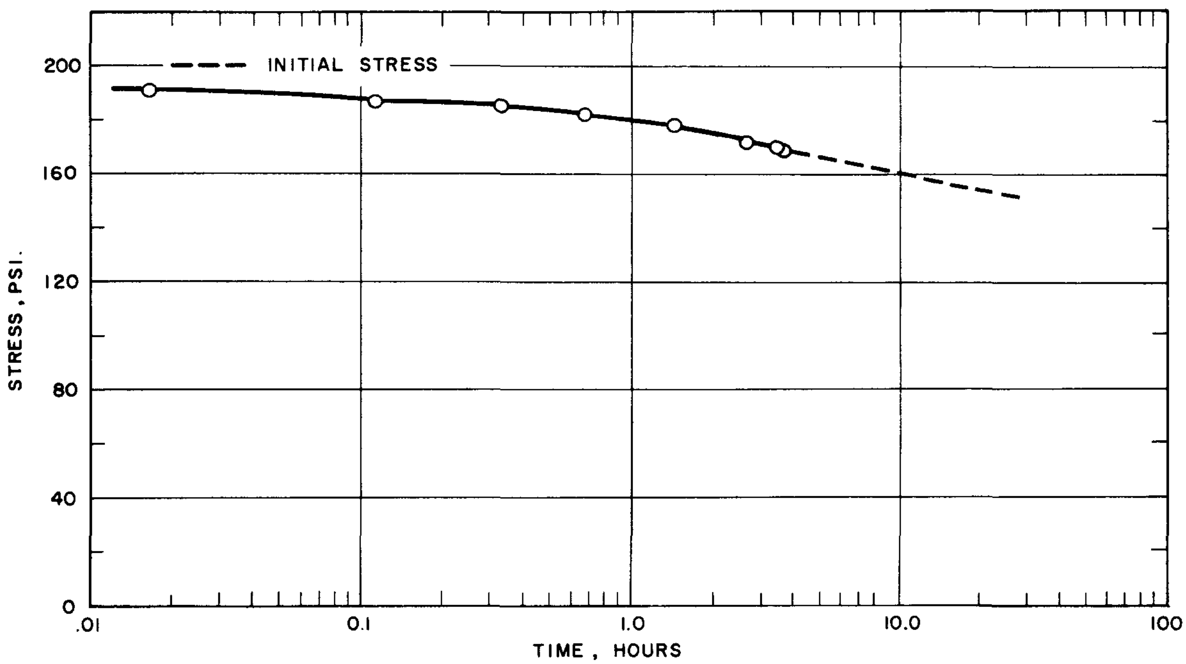

Figure 3 537366

Stress Relaxation of Graphite - WCB - Cloth at Room Temperature